



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

October 27, 2000

Camera type:	Zeiss RMK TOP 15*	Camera serial no.:	142832
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	144134
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Kucera International, Inc.  
Willoughby, Ohio

Reference: Z/I Imaging Corp. purchase order  
No. PO000935 dated October 11, 2000.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 152.844 mm

### II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-1	-2	-2	-1	1	2
Decentering (um)	0	0	0	1	1	1

#### Symmetric radial distortion parameters

$$\begin{aligned} K_0 &= 0.5233 \times 10^{-4} \\ K_1 &= -0.7315 \times 10^{-8} \\ K_2 &= 0.2015 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

#### Decentering distortion parameters

$$\begin{aligned} P_1 &= -0.7892 \times 10^{-7} \\ P_2 &= 0.1791 \times 10^{-7} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

#### Calibrated principal point

$$\begin{aligned} x_p &= 0.001 \text{ mm} \\ y_p &= -0.009 \text{ mm} \end{aligned}$$

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion ( $K_0, K_1, K_2, K_3, K_4$ ), Decentering Distortion ( $P_1, P_2, P_3, P_4$ ), and Calibrated Principal Point [point of symmetry] ( $x_p, y_p$ ) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation ( $\sigma$ ) of  $\pm 3$  microns.

\* Equipped with Forward Motion Compensation

### III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 105

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	134	113	113	95	113
Tangential lines	134	113	113	113	95	80	95

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

### IV. Filter Parallelism

The two surfaces of the USGS TOP 15 test filter KL-F (60%) No. 142399 are within 10 seconds of being parallel. This filter, in conjunction with the internal "B" filter, was used for the calibration.

### V. Shutter Calibration

Indicated time (sec)	Rise time ( $\mu$ sec)	Fall Time ( $\mu$ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/100	3863	3795	10.96	1/120	78
1/200	1817	1841	5.23	1/240	78
1/300	1249	1237	3.43	1/380	78
1/400	899	905	2.58	1/500	78
1/500	737	732	2.05	1/630	78

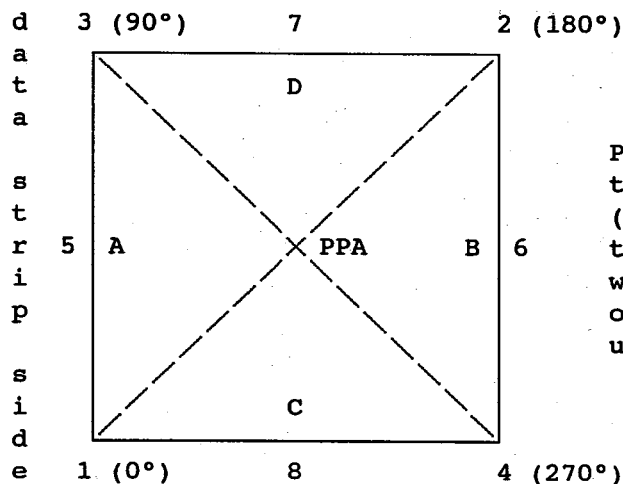
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

### VI. Magazine Platen

The platen mounted in T-MC film magazine No. 144870 does not depart from a true plane by more than 13  $\mu$ m (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "144389" in the data strip area for each exposure.

## VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	<u>X coordinate</u>	<u>Y coordinate</u>
Indicated principal point, corner fiducials	0.001 mm	-0.016 mm
Indicated principal point, midside fiducials	-0.001	-0.016
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) $x_p, y_p$	0.001	-0.009

### Fiducial Marks

1	-112.997 mm	-113.018 mm
2	113.004	112.989
3	-113.003	112.993
4	112.998	-113.018
5	-112.997	-0.014
6	113.006	-0.017
7	0.001	112.992
8	-0.003	-113.000

## VIII. Distances Between Fiducial Marks

### Corner fiducials (diagonals)

1-2: 319.618 mm      3-4: 319.621 mm

Lines joining these markers intersect at an angle of 89° 59' 53"

### Midside fiducials

5-6: 226.004 mm      7-8: 225.993 mm

Lines joining these markers intersect at an angle of 89° 59' 59" ,

### Corner fiducials (perimeter)

1-3: 226.010 mm      2-3: 226.007 mm

1-4: 225.995 mm      2-4: 226.007 mm

The method of measuring these distances is considered accurate within 0.003 mm

**Note:** For GPS applications, the nominal entrance pupil distance from the focal plane is 254 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

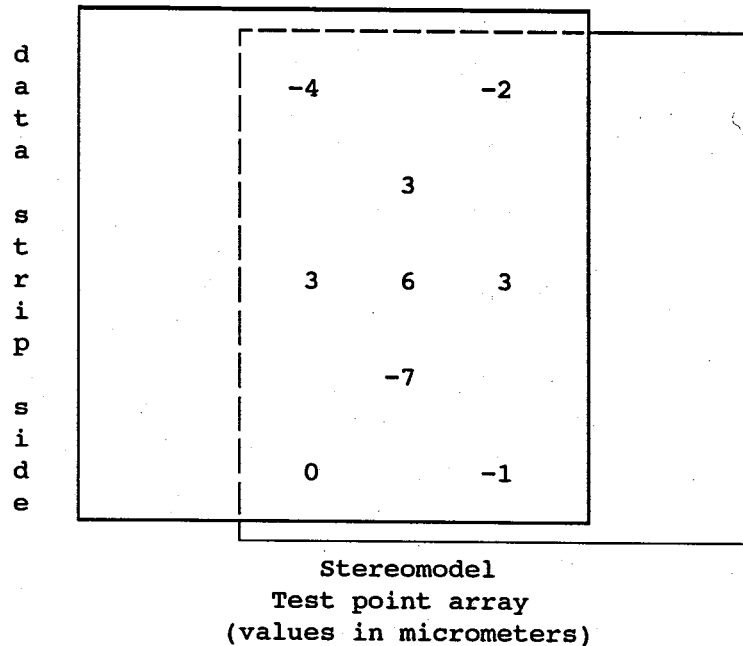
IX. Stereomodel Flatness

Magazine No.: 144870

Base/Height ratio: 0.6

Platen ID: 144389

Maximum angle of field tested: 40°



The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as  $\pm 5 \mu\text{m}$  from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 51

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	67	57	57	48	57	48	48
Tangential lines	67	57	48	48	57	48	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2528, dated February 16, 1999.

*for Christopher T. Kamm*  
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